

Shifts in Pennsylvania bat communities due to White-Nose Syndrome



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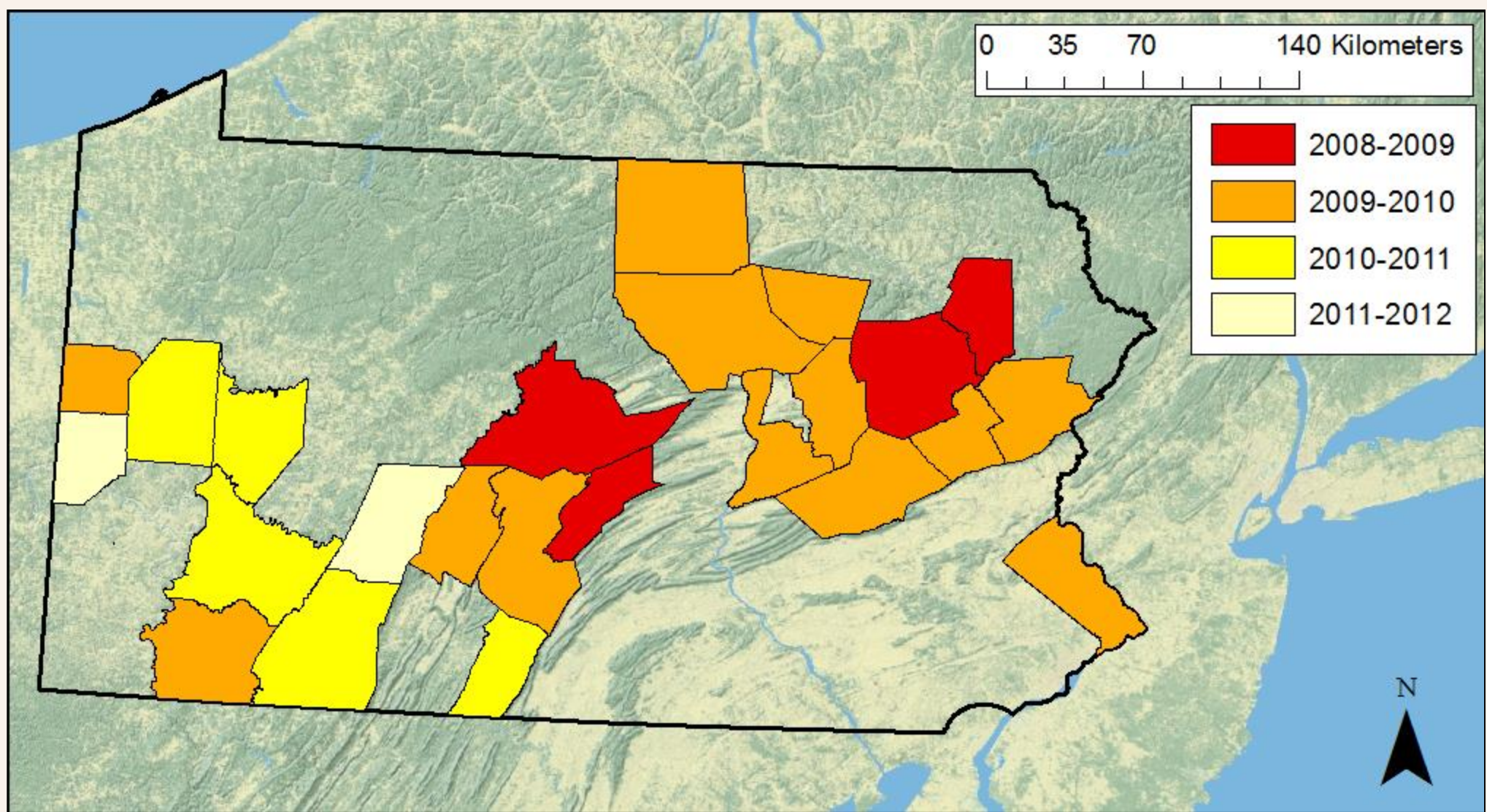
Background

- Bats are a diverse group of mammals whose individual species make up 20% of all known living mammals.
- In Pennsylvania, bats are a major predator of insects, consuming up to 20% of their weight in insects per night. Pest suppression by bats is estimated to value between \$3.7 billion to \$53 billion per year for the United States agriculture industry (Boyles et al. 2011).
- The emergence of white-nose syndrome (WNS) in North America has caused massive population declines in a number of hibernating bat species in Pennsylvania.
- WNS is caused by a species of fungus (named *Geomyces destructans*) found growing on the muzzles and wing membranes of hibernating bats. The fungus eats away at their wings, causing dehydration and death by starvation (Blehert et al. 2009).
- Over one million bats have died as a result of WNS, threatening at least one species, the little brown bat (*Myotis lucifugus*) with regional extinction in just 14 years (Frick et al. 2010). Hibernacula infected for multiple years experience up to 95% mortality.
- WNS originated in central New York and continues to spread west as far as Oklahoma and south into North Carolina, with highest concentration along the hibernacula of the Appalachian Mountain range.



Bat wing membrane with white-nose syndrome fungus (left). Hibernating bat covered in white-nose syndrome fungus (right). Photos courtesy of Ryan Moriarty/U.S. Fish and Wildlife Service and Ryan von Linden/NY Department of Environmental Conservation.

The spread of WNS has been staggered over several years in Pennsylvania. Hibernacula east of the Appalachian Mountains have been experiencing WNS infection a year longer than the west. This provides a unique opportunity to monitor the changes WNS may be causing to Pennsylvania's bat communities.



Map of white-nose syndrome's spread through Pennsylvania counties from 2008-2012.

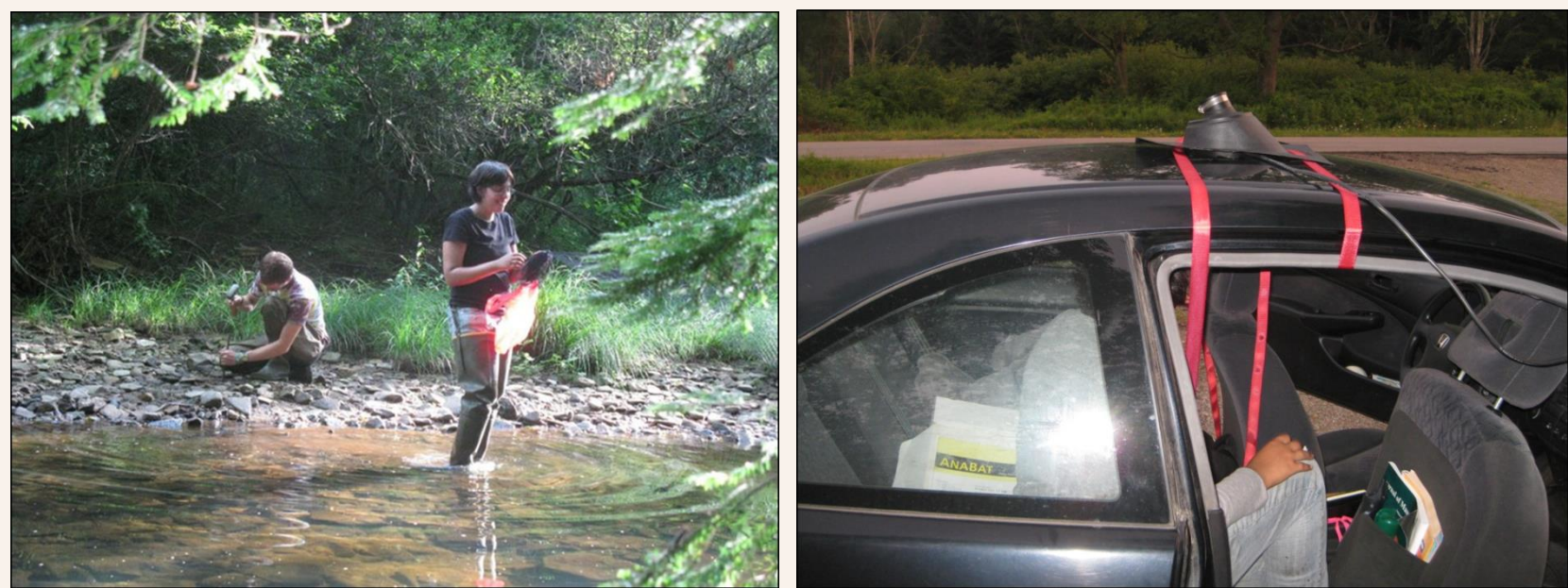
- WNS affects cave bats only. Cave bats are any bats that hibernate in caves during the winter months such as the little brown bat.
- Tree bats such as the red bat are presumably unaffected, as they move to warmer climates during the winter months.
- Therefore: WNS is causing variable mortality to bat species in Pennsylvania on a spatial and per-species scale.

Study Objectives

- To determine if summer bat activity and species diversity is lower in areas of prolonged white-nose syndrome infection.
- To determine if white-nose syndrome is changing species distributions of bats using a maximum entropy model in a novel way.

Methods

- I randomly selected twelve 50 by 50 km grids that served as study sites: 6 on the western side of the state and 6 on the east.
- Within each study sites were two 10 by 10 km sample sites where acoustic monitoring of bat activity occurred.
- I also selected 2 areas to conduct mist net surveys.
- All data was collected between May 15, 2011 and August 15, 2011 in a counter-clockwise fashion starting in the southern corner of the state.



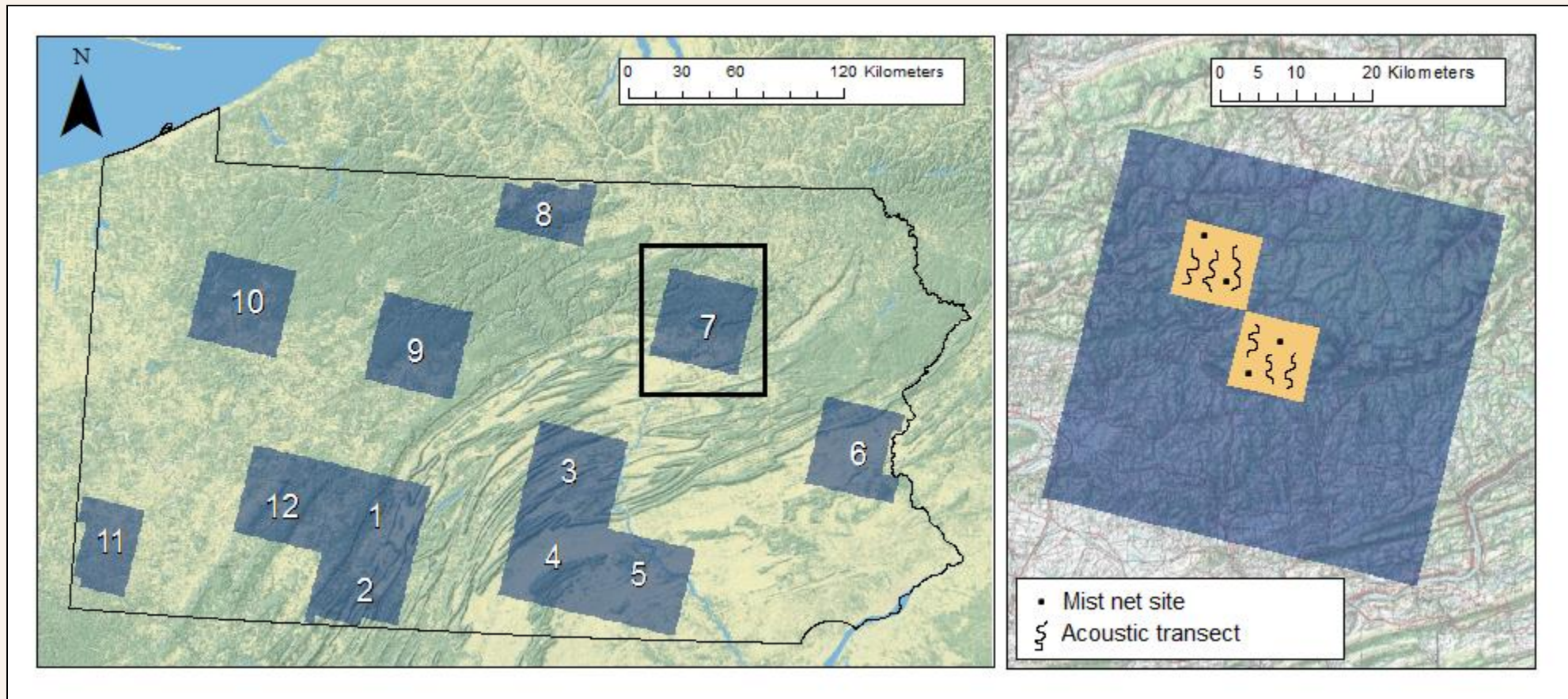
Setting up a mist net across a stream (left). Attaching an ANABAT SD1 to the top of a vehicle (left).

Acoustic monitoring:

- ANABAT SD1 bat detectors capable of digitally recording and storing bat echolocation calls were used for sampling.
- A microphone attached to the detector was fastened to the roof of a vehicle, while GPS units were plugged into the detectors to log the location of the vehicles every 2 seconds.
- Six road transects per sample site were conducted, each repeated 2-3 times each ($n = 72$).

Bat echolocation call identification:

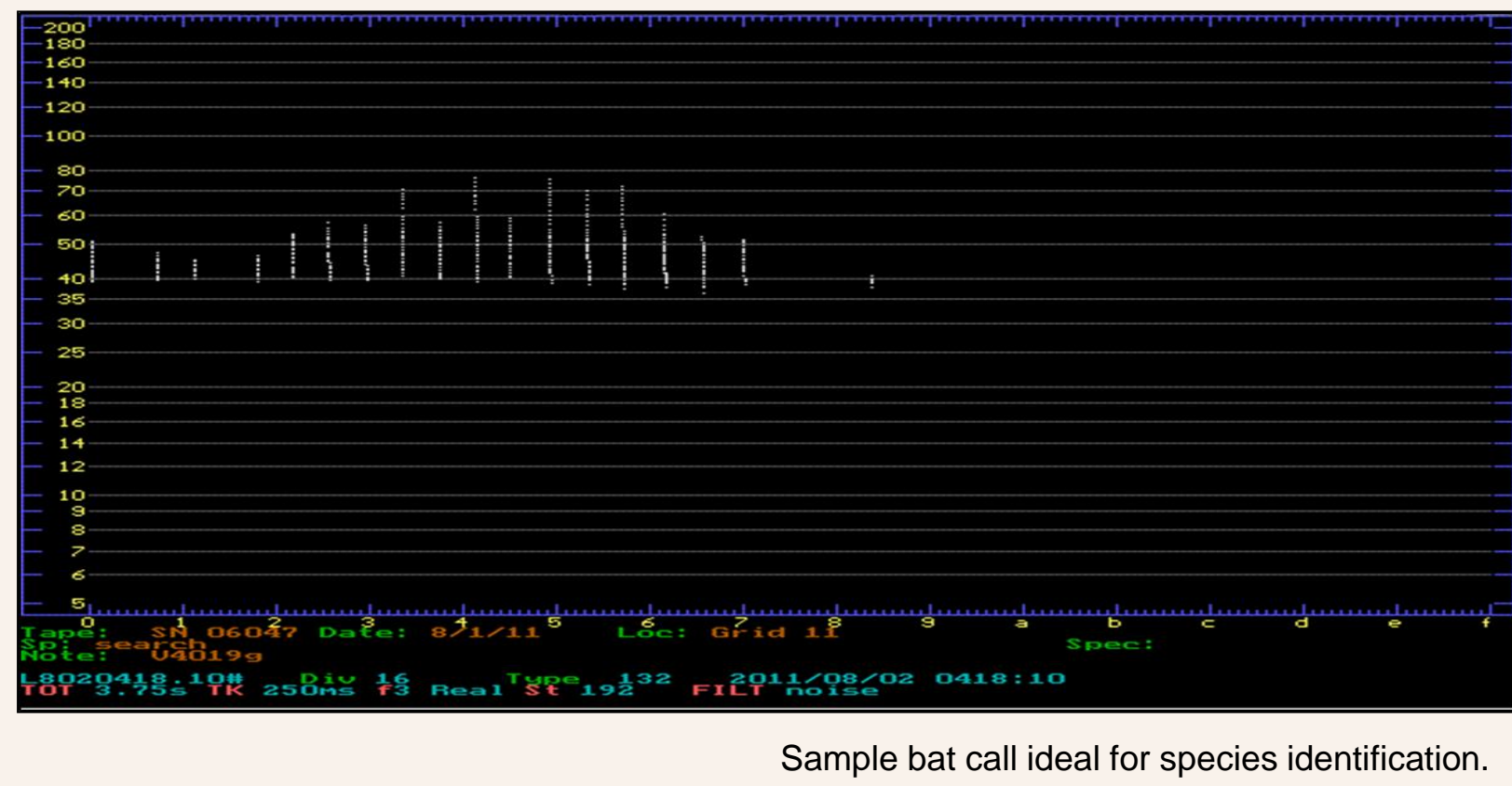
- I used program ANALOOK to clean echolocation calls and Program R with neural networks to identify them to species using a reference library of over 30,000 calls from the eastern United States.
- Raw bat calls were translated into call minutes to avoid bloated numbers due to multiple calls from the same individual bat.



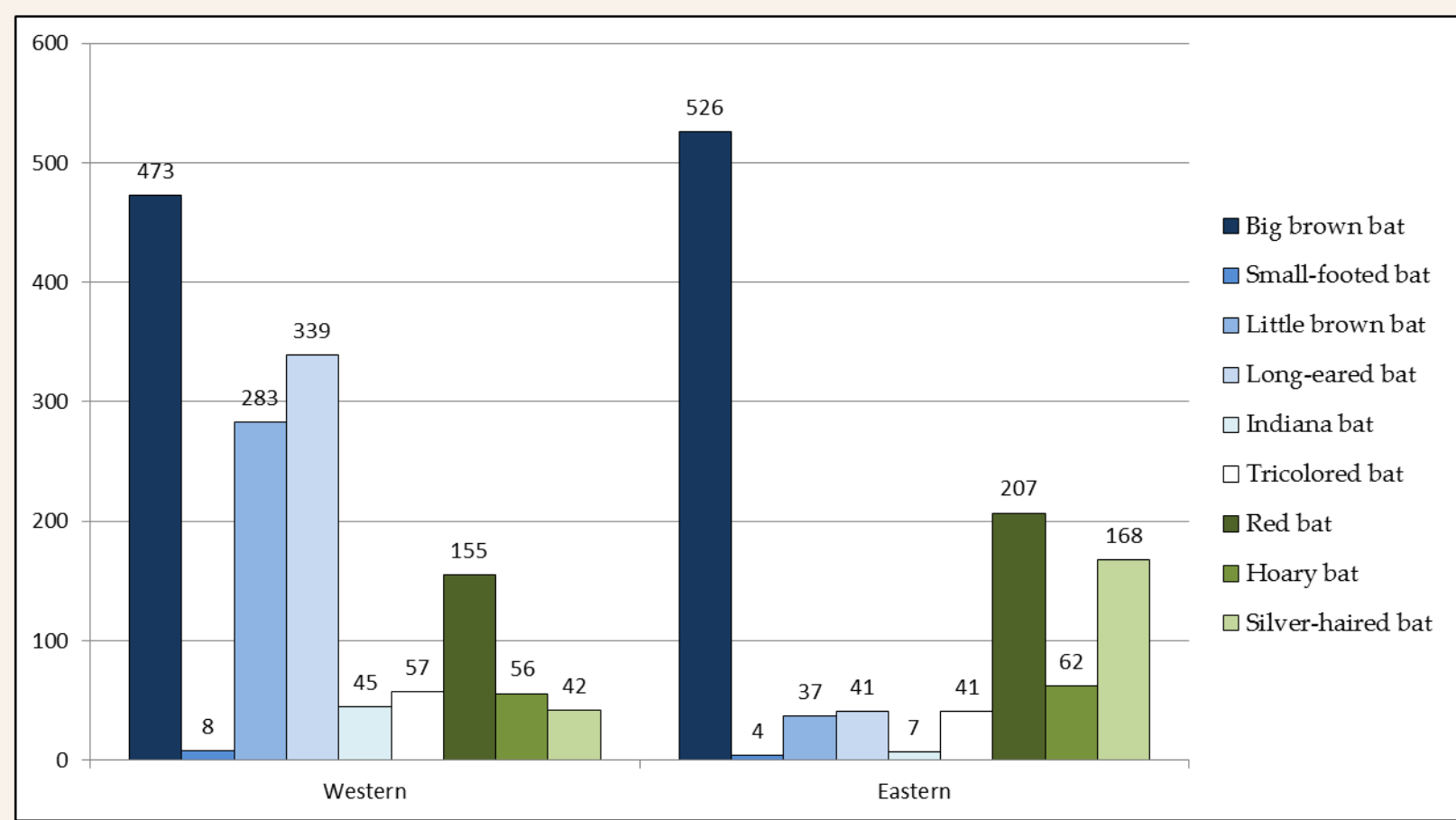
Location of the 12 50 by 50 km study sites throughout Pennsylvania (left). An example of the sampling protocol for one study site with two 10 by 10 km sampling sites, acoustic transects, and mist net sites (right).

Mist net surveys:

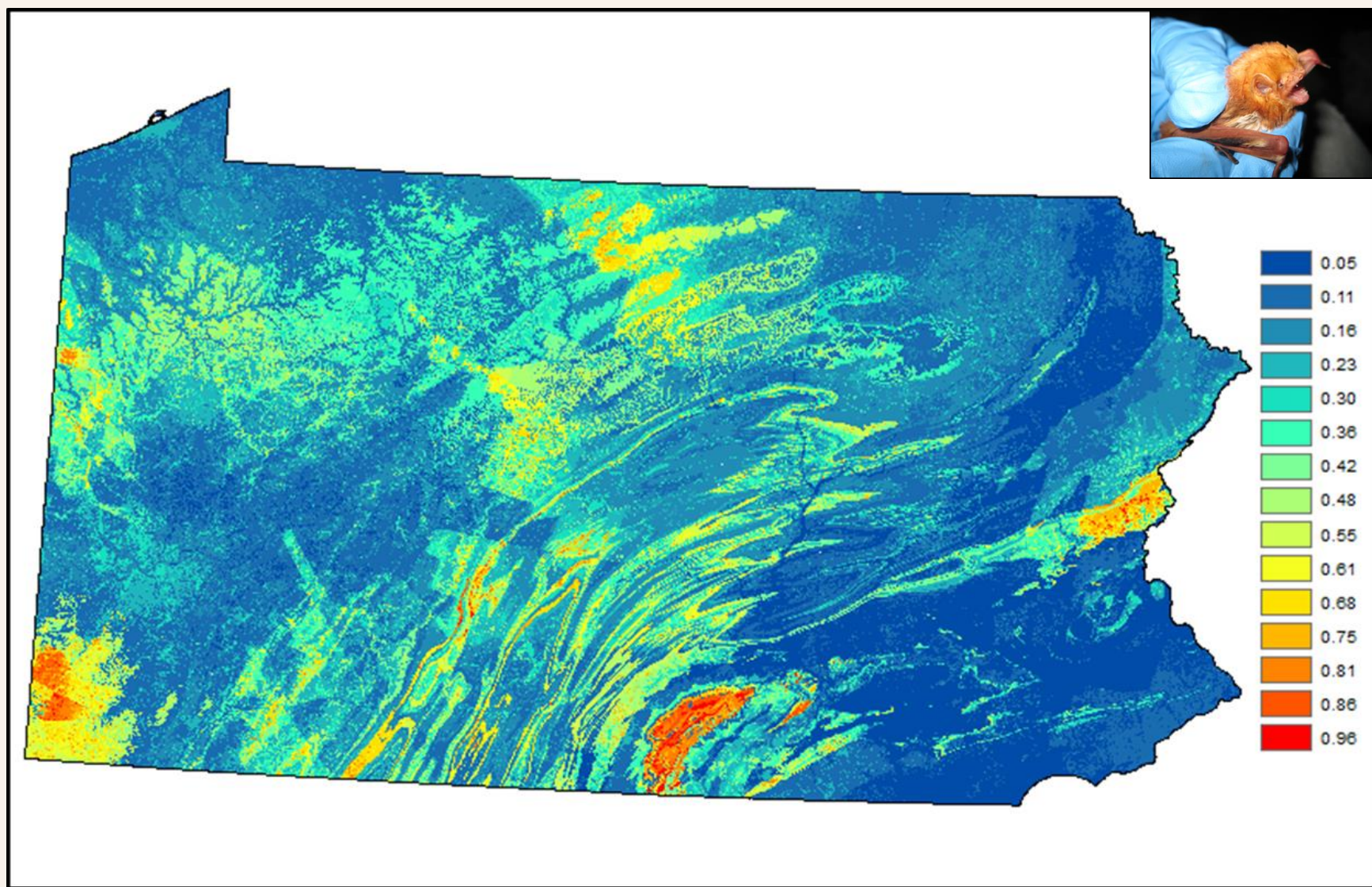
- Mist nets of various lengths were placed across possible bat flight corridors such as streams, trails, and primitive roads.
- Nets were opened at sunset and closed after 5 hours, checked every 15 min for captures.
- Captured bats were identified to species, sexed, and weighed before being released.
- A total of 24 net nights with 120 net hours were completed.



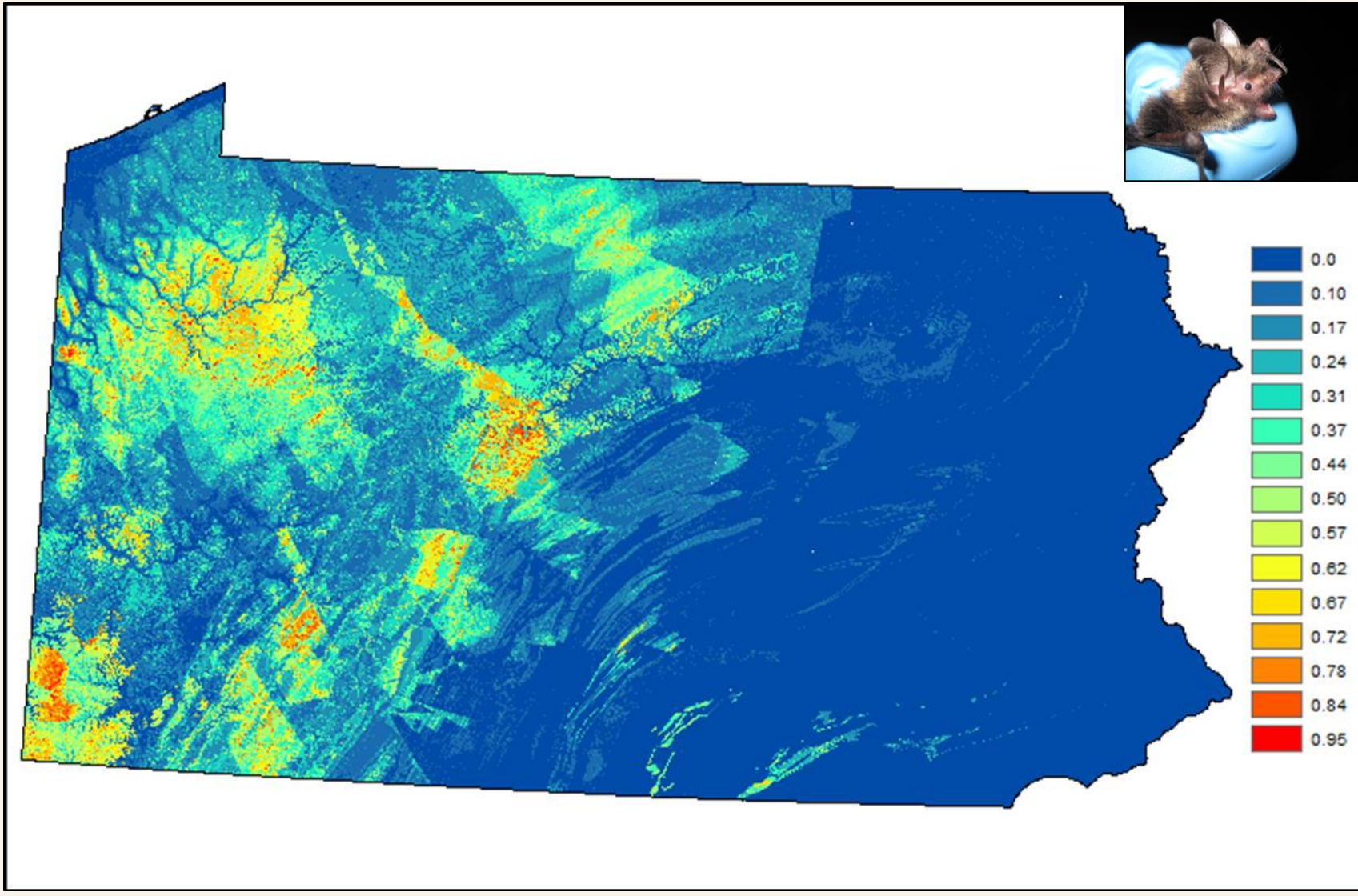
Sample bat call ideal for species identification.



Total call minutes identified to species of bat in the west and east portions of Pennsylvania. Blue colored bars indicate hibernating cave bats, while green colored bars indicate non-hibernating tree bats.



Maximum entropy model results for the red bat (*Lasiurus borealis*). Warmer colors indicate a greater probability of occurrence.



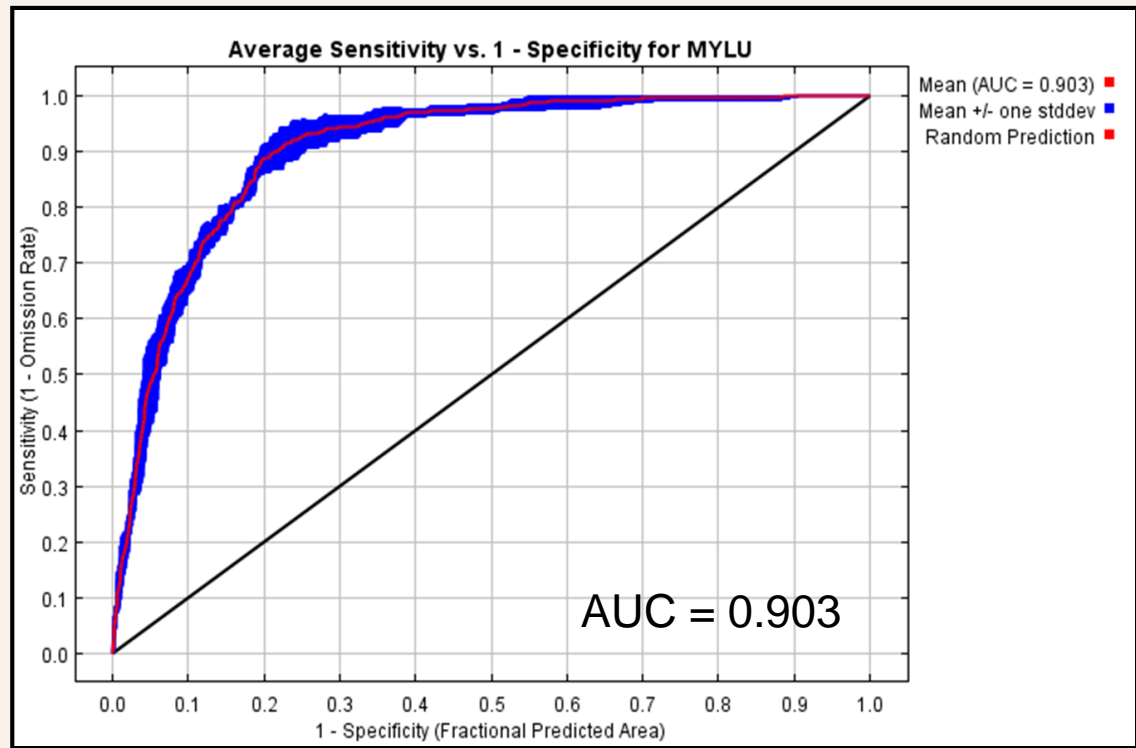
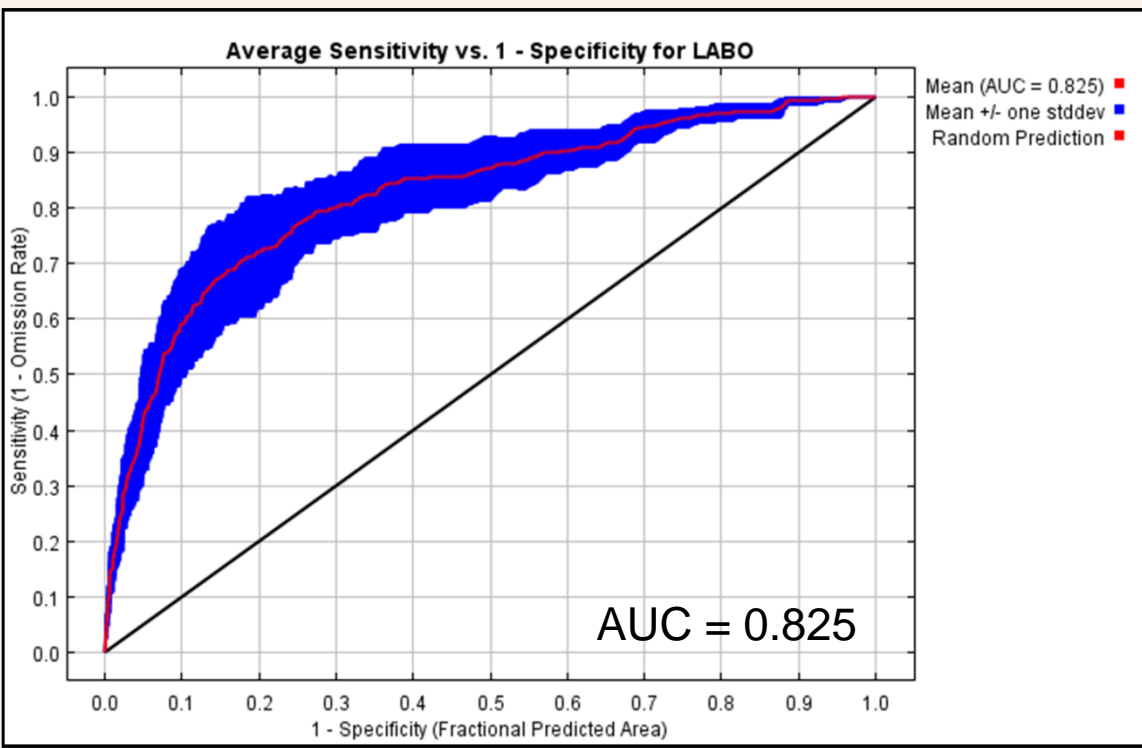
Maximum entropy model results for the little brown bat (*Myotis lucifugus*). Warmer colors indicate a greater probability of occurrence.

Red bat (*Lasiurus borealis*) model parameters.

Variable	Percent contribution
Geology	71.8
White-nose syndrome	16.2
Elevation	6.5
Land use	5.4
Wetlands	0.1

Little brown bat (*Myotis lucifugus*) model parameters.

Variable	Percent contribution
White-nose syndrome	54.3
Geology	24.3
Elevation	14.8
Land use	6.3
Wetlands	0.3



Receiver operating characteristic curves for the red bat model (left) and the little brown bat model (right). An AUC value closer to 1 is an indication of the model being a good fit for the data.

Discussion

Summer bat activity and diversity appears lower in areas of prolonged white-nose syndrome infection, but data from this study did not find this difference to be significant. The MaxEnt models revealed that WNS as a habitat variable explains most of the observed distribution of little brown bats in Pennsylvania, while geology is the main driver in red bats. The most important geology types for red bat distributions included limestone, dolomite, and sandstone formations. Other longer-term studies looking at summer activity of bats after WNS occurrence have shown greatly reduced activity and diversity levels (Brooks 2011, Ford et al. 2011). The little brown bat was once the most common and widespread bat in Pennsylvania, however my MaxEnt model shows their distributions are now limited to west of the Appalachian Mountains.

The standardized methods I used to monitor bat activity are used in other areas throughout the United States, making my data directly comparable to those areas. Monitoring of active season bat populations in Pennsylvania is limited to the volunteer-led Appalachian Bat Count. This survey focuses on numbers, but not individual species, and may be missing crucial information about changes in bat populations at the community level. My study provides the first state-wide standardized bat activity data known for the state.

MaxEnt modeling is a useful tool in the study of bat distributions. It can provide valuable information in the form of what habitats are important to the species and which areas should be of greatest conservation concern. Additionally, this modeling method can be used with ease to predict species response to environmental changes such as further WNS spread or climate change.

Acknowledgements

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References

- Blehert, D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Berlowksi-Zier, E. L. Buckles, J. T. H. Coleman, S. R. Darling, A. Gargas, R. Niver, J. C. Okoniewski, R. J. Rudd, and W. B. Stone. 2009. Bat white-nose syndrome: an emerging fungal pathogen? *Science* 323:227-227.
- Boyles, J. G., P. M. Cryan, G. F. McCracken, and T. H. Kunz. 2011. Economic importance of bats in agriculture. *Science* 332:41-42.
- Brooks, R. T. 2011. Declines in summer bat activity in central New England 4 years following the initial detection of white-nose syndrome. *Biodiversity and Conservation* 20:2537-2541.
- Elith, J., S. J. Phillips, T. Hastie, M. Dudik, Y. E. Chee, and C. J. Yates. 2011. A statistical explanation of MaxEnt for ecologists. *Diversity and Distributions* 17:43-57.
- Foley, J., D. Clifford, K. Castle, P. Cryan, and R. S. Ostfeld. 2011. Investigating and managing the rapid emergence of white-nose syndrome, a novel, fatal, infectious disease of hibernating bats. *Conservation Biology* 25:223-231.
- Ford, W. M., E. R. Britzke, C. A. Dobony, J. L. Rodrigue, and J. B. Johnson. 2011. Patterns of acoustical activity of bats prior to and following white-nose syndrome occurrence. *Journal of Fish and Wildlife Management*. 2:125-134.
- Frick, W. F., J. F. Pollock, A. C. Hicks, K. E. Langwig, D. S. Reynolds, G. G. Turner, C. M. Butchkoski, and T. H. Kunz. 2010. An emerging disease causes regional population collapse of a common North American bat species. *Science* 329:679-682.
- Jones, G., D. S. Jacobs, T. H. Kunz, M. R. Willig, and P. A. Racey. 2009. Carpe noctem: the importance of bats as bioindicators. *Endangered Species Research* 8:93-115.